ATOS

Automatic Transformer Observing System

Application Note

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Contents

1 About TR (Turns Ratio) Measurement

1.1 How to choose Test Voltage

The easiest way to choose a good test voltage for a power transformer is setting the voltage in the transformer profile of TR-MARK III to ‘Auto’. The device will usually find the optimal voltage.

If you want to make your own decision you will have no other choice than trying and keep an eye on the current displayed. You should try to get a maximally high test voltage, but your testing current should not exceed ~5mA.

1.2 Using Current and Phase Angle Information

Current and Phase angle are no primary results of a turns ratio meter. But they can be helpful indicators of something being wrong in a transformer under test.

If a transformer is ok, turns ratio, current and phase angle will be very similar on each Phase. It’s always good to watch out for differences between the three phases.

The current value of a phase can also be helpful to detect a shortcut between one or a small number of turns of a winding. Especially when testing a high ratio transformer you may not see a difference between a turns ratio of two phases, but you will take notice of a higher current of the phase affected by the short cut.

2 About WR (Winding Resistance) Measurement

There are tow big issues about WR measurement:

1) Energizing the core of the transformer under test
2) Temperature rise because of the measuring current.

2.1 Energizing the Core

To Energize a power transformer, usually a current of 1% of its nominal current is needed. To energize a transformer means nothing else, than completely magnetize its iron core. That's necessary to reduce noise influence. A magnetized core reduces inductivity of the corresponding windings. If for instance an AC noise current is coupled to a not magnetized core, the windings or let's say coil, it will react with it's full inductance where the resulting noise voltage U_n will be

$$U_n = -L\frac{\delta I}{\delta t}$$

Fully magnetizing the core means bringing L to it's minimum, what results in a minimal noise voltage U_n.

But, if energizing a transformer is a good thing, then why not using the maximal current of your winding resistance meter and maximizing the signal? The following chapter will answer this issue.

2.2 Rise of Temperature and it's Influence

Copper typically has a temperature coefficient about 0.004 1/K. That means nothing else, than if your transformer changes temperature 1°C during the measurement, your measured resistance will change 0.004 * $R_{Winding}$. A temperature change of 3° will result in an error of 1.2%.

With the measuring current, also electrical power is led into the transformer, that converts into heating power because of the winding resistance.

$P = I^2 * R$ means that doubling the measuring current results in quadrupling thermal power. That's why you are interested in keeping the measuring current as low as possible.

Of course, you could measure temperature during your measurement and use the temperature correction. But be aware that this temperature change is not easy to measure, because this heating is a local effect. Usually only one coil is supplied with the measuring current at time. And you will not be able to measure directly on the windings.

2.3 A winning compromise

Most standards recommend to measure with 15% of nominal current of a transformer. Raytech recommends 10% of nominal current, to get the best measuring performance with our devices.

3 Measuring with two WR-Meters at once

It is recommended to read chapter ‘2 About WR (Winding Resistance) Measurement’ before this chapter.

If your ATOS is equipped with two winding resistance meters, it is always recommended to start with the WR-meter on the high voltage side because

- The core will be energized faster
- The voltage ramp will be transformed down to the low voltage side.
  That means, that the WR-meter there will never have a problem.
- If you have a really big transformer for high Power and high currents, you will have a better chance to reach saturation with the available current of your WR-meter.

NOTE

⇒ If your ATOS is equipped with two winding resistance meters, always start measurement on high voltage side first.
The winding resistance meter on the high voltage side should also be the last one to stop measurement.

If you do this, you must consider the following points:

- Take always the 2 windings on the same coil and connect them in the same current direction. To find out the corresponding windings of a transformer, you can use the table from ‘A Transformer Connection Schemes’.
- Start the measurement on the high voltage side first. Only when the current is flowing on the high voltage side, press “Start” on the instrument which is connected on the low voltage side.
- After you get the test results, stop first the current on the low-voltage-side and afterwards stop the measurement on the high-voltage-side.

Example:

There is a transformer prepared for measurement with the following nameplate:

HV: 66KV, 78.8A

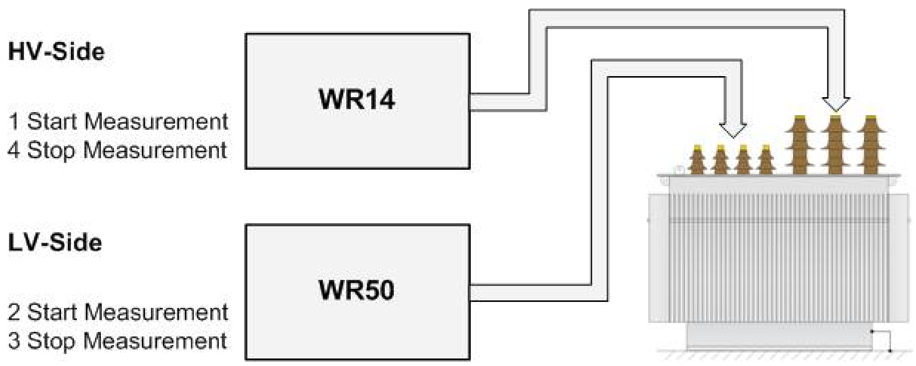
LV: 11KV, 473A

Connect the WR14 or its Multiplexer to the high voltage side of the transformer, the measuring cables from the WR50 or its Multiplexer to the corresponding winding of the low voltage side.

Start first the measurement on the high voltage side with about 7A.

Only when the current is flowing and stable on the high voltage side, press “Start” on the low voltage side on a current range of 40A.

When you have all your results, stop first the current on the low voltage side and afterwards stop the measurement on the high voltage side.



4 Demagnetizing

Energizing magnetized transformers

Problems can be created when the core of a transformer becomes magnetized prior to being energized for use. Damage to the insulation and deformation of the windings are two of the most common side effects.

Generally, Transformer cores, during operation are magnetized, demagnetized and then magnetized and demagnetized in the opposite direction for each sine wave cycle.

It is not easy to determine the magnitude the core is magnetized at the moment the Alternating Current source is switched off. The larger the hysteresis of the iron in the core material, the greater the magnetization level. The magnitude of magnetization depends upon the moment the transformer is switched off and the applied voltage level during the power on state.

The highest magnetization in this scenario occurs when a transformer is switched off right at the moment the voltage source sine wave crosses the zero-line.

Transformer cores are also magnetized after having a Direct Current source flow in a winding. For example, the application of Direct Current when performing a winding resistance test. After measuring the Winding Resistance the core is magnetized to its' maximum Hysteresis.

Both of these scenarios can leave the core in an unpredictable state which can cause damage when energized. These problems can be eliminated if the transformer is demagnetized prior to being energized for use.

Conclusion

• A transformer is magnetized when power is switched off. Even if a transformer is completely de-energized, it can still be in a magnetized state!

• After performing DC tests on a transformer winding, the core is magnetized.

Consequences of energizing a magnetized transformer

When a magnetized transformer is switched back on line, it is quite possible, depending upon the position of the sine wave and other variables, that inrush current can exceed 8 times the nominal current flow. This hazardous situation may cause tripping of over-current relays, damage to the insulation medium and deformation of the transformer windings.

Procedure for eliminating the magnetized state of a transformer

One option that can be taken to safely switch a transformer back on line and avoid a dangerous and damaging situation is to apply a reduced AC voltage source and increase the voltage level to the operating voltage level. Under controlled conditions this may be possible. However, this undertaking may not be theoretically possible when energizing a transformer on site. Equipment required to fully demagnetize a transformer in this manner is large and expensive.

or

A better solution is the new Raytech Winding Resistance Meter, WR-Series.

These easy to use systems are recognized throughout the World for Precision Winding Resistance measurements. A unique and new feature built into the WR-series is the ability to Automatically Demagnetize a Transformer core on site.

Avoid unnecessary damage and unsafe conditions when energizing a transformer; use one of the Raytech WR-series instruments and be sure.

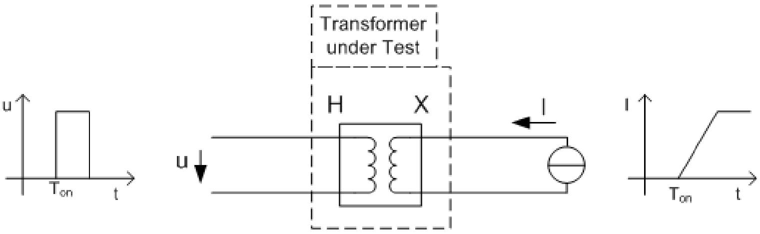
Parameters for demagnetizing

The Current of the WR series test system should be applied on the high inductive or High Voltage side of the transformer. Although the potential cables from Channel 1 must be connected.

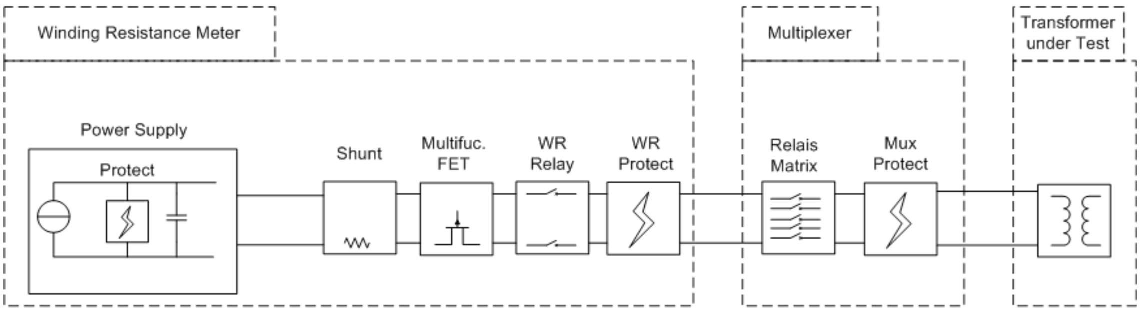
The optimal demagnetizing current to be used is the same as the measuring current used during Winding Resistance Measurement or the maximum allowed for the nominal current level of the high voltage side.

5 ATOS protection systems

For several reasons, voltages may occur at the transformer under test. A typical reason is when a winding resistance measurement on the low voltage side of a Transformer is started, while the core is not saturated. Because of the current ramp on the low voltage side, a voltage higher than the source voltage will be induced on the high voltage side.



To protect ATOS devices from overvoltage, the Multiplexers and winding resistance meters (WR) contain crowbar circuits and other protecting elements. The following schematic shows the protection structure of a standard ATOS.



The crowbar circuit called ‘Mux Protect’ avoids flashover in the relay contacts of a Multiplexer. This circuit shortens the input when voltage rises above 600V.

A connected winding resistance meter will limit the voltage at a much lower level. It contains two protection circuits, one near the input and one is built in its power supply. In some protection cases WR Relays can be opened.

All protection elements remain passive, as long as their protection condition is not fulfilled. A user will not take notice of their presence during a normal measuring cycle.
If a protection element is activated, the user will be informed by touch screen or remote control.

6 Removing a Multiplexer from a ATOS

One day, for a certain reason you may wish to use one of your Multiplexers with another Raytech WR-Meter. That’s easy to do. You just have to remove it, put a Mux Intercom dummy plug to the open Mux Intercom cable end and if necessary re-arrange the option cables.

The following instructions show this step by step.

1 Remove the selected Multiplexer

2. Grab the Mux Intercom Dummy Plug…

… and connect it to the open Mux Intercom cable end.

3. Make sure that the remaining Multiplexers ‘Option In’ are connected directly to the ‘Option Out’ of a WR, or via another Multiplexer. The system will not work, if the ‘Option In’ of a Multiplexer remains open.

The advantage of this procedure is, that the addresses of the Multiplexers (A,B and C) remain for each device the same. They are allocated by the Mux Intercom cable.
Your controlling remote software will still work together with the ATOS, you do not have to change anything. Of course, you can also not use the removed Multiplexer with the software.

7 Transformer Connection Schemes

7.1 How to use the following Table

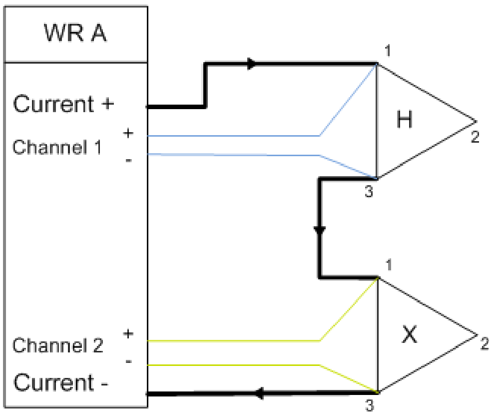
It makes sense to measure the high voltage side in series to the low voltage side to magnetize the transformer faster. Take always the 2 windings on the same coil in the same current direction.

The only thing you have to do is using the table in ‘7.2 Transformer Connection Table’, and set Multiplexer A to the values in column ‘Channel 1’ and Multiplexer B to column ‘Channel 2’

NOTE

⇒ Use from the table in ‘7.2 Transformer Connection Table’
the setting of ‘Cahnnel 1’ for Mux A
and the setting of ‘Channel 2’ for Mux B.

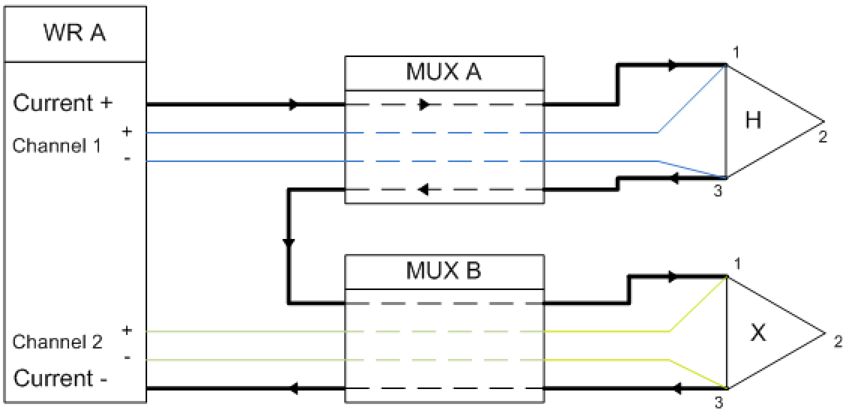
The following example with a D:d-0 transformer will help to understand that.



The table sais to put Current + to H1, a jumper from H3 to X1 and put Current – to X3.
Channel 1 is putted from H1 to H3
Cahnnel 2 is putted from X1 to X3

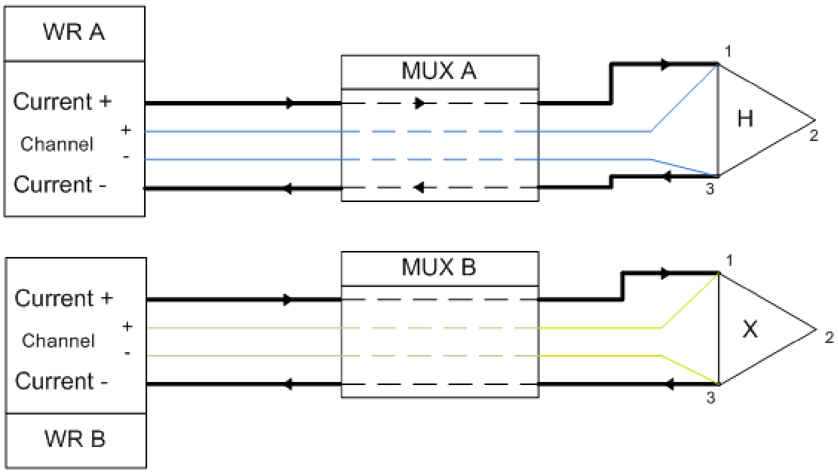
As you can see in the diagram on the left, current flows on both winding system from “up to down”

Now lets see what happens, when we use the same winding resitance meter and two Multiplexers and set them, as the table sais, to Mux A: H1:H3 and Mux B: X1:X3.



The current flow in the winding systems is exactly the same.

And of course, the same measurement can also be done with two winding resistance meters and two Multiplexers.



As the system cabling is different for one and two winding resistance meters, nothing changes in the control scheme of Multiplexers.

7.2 Transformer Connection Table

Transformer type			Current Connection			Sense Connection			
			Current +	Jumper	Current -	Channel 1		Channel 2	
P	S	V				+	-	+	-
D	d	0	H1	H3:X1	X3	H1	H3	X1	X3
			H2	H1:X2	X1	H2	H1	X2	X1
			H3	H2:X3	X2	H3	H2	X3	X2
		2	H1	H3:X1	X2	H1	H3	X1	X2
			H2	H1:X2	X3	H2	H1	X2	X3
			H3	H2:X3	X1	H3	H2	X3	X1
		4	H1	H3:X3	X2	H1	H3	X3	X2
			H2	H1:X1	X3	H2	H1	X1	X3
			H3	H2:X2	X1	H3	H2	X2	X1
		6	H1	H3:X3	X1	H1	H3	X3	X1
			H2	H1:X1	X2	H2	H1	X1	X2
			H3	H2:X2	X3	H3	H2	X2	X3
		8	H1	H3:X2	X1	H1	H3	X2	X1
			H2	H1:X3	X2	H2	H1	X3	X2
			H3	H2:X1	X3	H3	H2	X1	X3
		10	H1	H3:X2	X3	H1	H3	X2	X3
			H2	H1:X3	X1	H2	H1	X3	X1
			H3	H2:X1	X2	H3	H2	X1	X2
	yn	1	H1	H3:X1	X0	H1	H3	X1	X0
			H2	H1:X2	X0	H2	H1	X2	X0
			H3	H2:X3	X0	H3	H2	X3	X0
		5	H1	H3:X3	X0	H1	H3	X3	X0
			H2	H1:X1	X0	H2	H1	X1	X0
			H3	H2:X2	X0	H3	H2	X2	X0
		7	H1	H3:X0	X1	H1	H3	X0	X1
			H2	H1:X0	X2	H2	H1	X0	X2
			H3	H2:X0	X3	H3	H2	X0	X3
		11	H1	H3:X0	X3	H1	H3	X0	X3
			H2	H1:X0	X1	H2	H1	X0	X1
			H3	H2:X0	X2	H3	H2	X0	X2

Transformer type			Current Connection			Sense Connection			
			Current +	Jumper	Current -	Channel 1		Channel 2	
P	S	V				+	-	+	-
D	y	1	H1	H3:X1	X3	H1	H3	X1	X3
			H2	H1:X2	X1	H2	H1	X2	X1
			H3	H2:X3	X2	H3	H2	X3	X2
		5	H1	H3:X3	X1	H1	H3	X3	X1
			H2	H1:X1	X2	H2	H1	X1	X2
			H3	H2:X2	X3	H3	H2	X2	X3
		7	H1	H3:X3	X1	H1	H3	X3	X1
			H2	H1:X1	X2	H2	H1	X1	X2
			H3	H2:X2	X3	H3	H2	X2	X3
		11	H1	H3:X1	X3	H1	H3	X1	X3
			H2	H1:X2	X1	H2	H1	X2	X1
			H3	H2:X3	X2	H3	H2	X3	X2
Yn	d	1	H1	H0:X1	X2	H1	H0	X1	X2
			H2	H0:X2	X3	H2	H0	X2	X3
			H3	H0:X3	X1	H3	H0	X3	X1
		5	H1	H0:X3	X1	H1	H0	X3	X1
			H2	H0:X1	X2	H2	H0	X1	X2
			H3	H0:X2	X3	H3	H0	X2	X3
		7	H1	H0:X2	X1	H1	H0	X2	X1
			H2	H0:X3	X2	H2	H0	X3	X2
			H3	H0:X1	X3	H3	H0	X1	X3
		11	H1	H0:X1	X3	H1	H0	X1	X3
			H2	H0:X2	X1	H2	H0	X2	X1
			H3	H0:X3	X2	H3	H0	X3	X2
	yn	0	H1	H0:X1	X0	H1	H0	X1	X0
			H2	H0:X2	X0	H2	H0	X2	X0
			H3	H0:X3	X0	H3	H0	X3	X0
		6	H1	H0:X0	X1	H1	H0	X0	X1
			H2	H0:X0	X2	H2	H0	X0	X2
			H3	H0:X0	X3	H3	H0	X0	X3
	y	0	H1	H3:X1	X3	H1	H3	X1	X3
			H2	H1:X2	X1	H2	H1	X2	X1
			H3	H2:X3	X2	H3	H2	X3	X2
		6	H1	H3:X3	X1	H1	H3	X3	X1
			H2	H1:X1	X2	H2	H1	X1	X2
			H3	H2:X2	X3	H3	H2	X2	X3

Transformer type			Current Connection			Sense Connection			
						Channel 1		Channel 2	
P	S	V	Current +	Jumper	Current -	+	-	+	-
Y	d	1	H1	H3:X1	X3	H1	H3	X1	X3
			H2	H1:X2	X1	H2	H1	X2	X1
			H3	H2:X3	X2	H3	H2	X3	X2
		5	H1	H3:X3	X2	H1	H3	X3	X2
			H2	H1:X1	X3	H2	H1	X1	X3
			H3	H2:X2	X1	H3	H2	X2	X1
		7	H1	H3:X2	X1	H1	H3	X2	X1
			H2	H1:X3	X2	H2	H1	X3	X2
			H3	H2:X1	X3	H3	H2	X1	X3
		11	H1	H3:X1	X3	H1	H3	X1	X3
			H2	H1:X2	X1	H2	H1	X2	X1
			H3	H2:X3	X2	H3	H2	X3	X2
	yn	0	H1	H3:X1	X0	H1	H3	X1	X0
			H2	H1:X2	X0	H2	H1	X2	X0
			H3	H2:X3	X0	H3	H2	X3	X0
		6	H1	H3:X0	X1	H1	H3	X0	X1
			H2	H1:X0	X2	H2	H1	X0	X2
			H3	H2:X0	X3	H3	H2	X0	X3
	y	0	H1	H3:X1	X3	H1	H3	X1	X3
			H2	H1:X2	X1	H2	H1	X2	X1
			H3	H2:X3	X2	H3	H2	X3	X2
		6	H1	H3:X3	X1	H1	H3	X3	X1
			H2	H1:X1	X2	H2	H1	X1	X2
			H3	H2:X2	X3	H3	H2	X2	X3
S	s	0	H1	H0:X1	X0	H1	H0	X1	X0
		6	H1	H0:X0	X1	H1	H0	X0	X1

The table is in ANSI standard. You can change it e.g. to the ICE standard by substitute
H1 to 1U
H2 to 1V
H3 to 1W…

A Troubleshooting

<u>A device does not display anything</u>

Check mains fuses on the Integrated Safety Unit and check fuse in the affected device. Note that WR100-12R has two fuses on the back panel.

<u>A touch Panel does not work:</u>

Please connect any USB mouse to the USB port on the front panel. Raytech devices will display a cursor when a mouse is connected.

<u>Measurement can not be started</u>**:**

Is the Emergency stop switch pushed in? Turn to release it.
Or is the external safety interlock open?

<u>USB Memory Stick does not work:</u>

There are a few unsupported memory sticks available on the market. Please use another model and try again.

NOTE

⇒ ATOS is designed to be trouble free.
If problems or questions do arise please contact your nearest representative or our service support group in Switzerland.

B Contacts

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